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14. ABSTRACT
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A 3-kV, 3-Ω, FAST RISETIME PULSER*

J. T. Naff and J. W. Douglas

Physics International Company
2700 Merced Street
San Leandro, California 94577

Abstract

A very fast risetime, low-impedance pulse generator has been constructed and tested. The pulser produces an approximate double exponential pulse at 3 kV into a 3-Ω load. The 10 to 90 risetime is 600 ps and 1/e falltime is 30 ns. The pulse generator design is a dynamic peaking capacitor circuit. The pulser output consists of 16 parallel 50-Ω cables. The output switch of the peaking capacitor circuit has 16 individual spark gaps operating synchronously. The main switch is triggered from an external source providing synchronization of the output pulse with a low-level initiation pulse. In the design, internal resonances are avoided by careful design of all components including the capacitors. A description of the design and operation of the system will be given.

Introduction

The fast risetime pulser delivers a 3-kV pulse into a 3-Ω load with a 10 to 90 risetime of 600 ps and a 1/e falltime of 30 ns. The pulse approximates a double exponential. Figure 1 is a photograph of the pulser. The pulser specifications are summarized in Figure 2. The pulser is of rugged construction and adjustments are seldom required. The pulser is operable at rates up to several Hz.

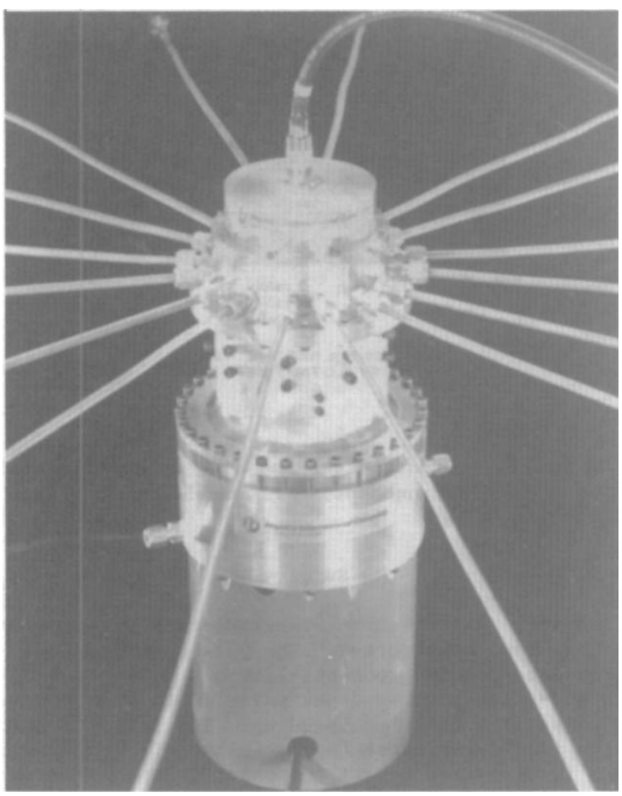

Figure 1. Pulser drives a nominal 3-Ω load (16 50-Ω cables).

Peak Voltage	**−3 kV**
10-90 Risetime (1 output)	**0.6 ns**
Jitter Between Output Cables	**<0.2 ns**
Command Jitter	**<5 ns**
Number of Outputs	**16 of 50 Ω each**

Figure 2. Pulser output specifications.

Functionally the pulser consists of a storage capacitor which is discharged through a triggered (main) gas switch to a peaking capacitor, and then through a multisite, self-breaking gas output switch. Both switches are UV-illuminated and use air as the switching medium. A schematic of the pulser is shown in Figure 3. There is one input for high voltage dc and two inputs (one for each switch) for switch trigger and UV-illumination pulses. The output connection consists of sixteen 50-Ω semirigid coaxial cables arranged radially around the end of the pulser.

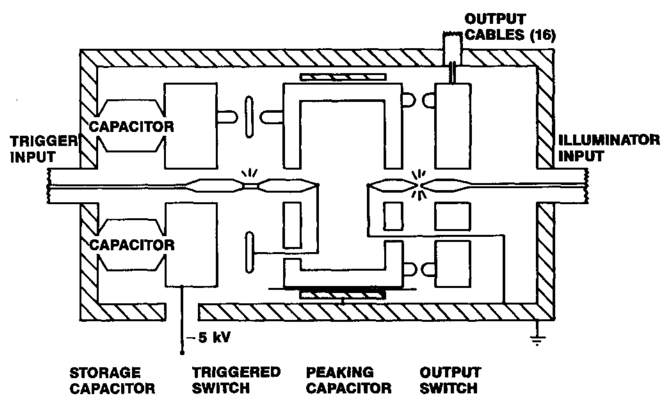

Figure 3. Schematic of fast risetime pulser.

Design

The overall size of the pulser is kept small to minimize inductance. The exterior of the pulser is grounded to minimize the generation of electromagnetic interference. An electrical schematic of the pulser is shown in Figure 4.

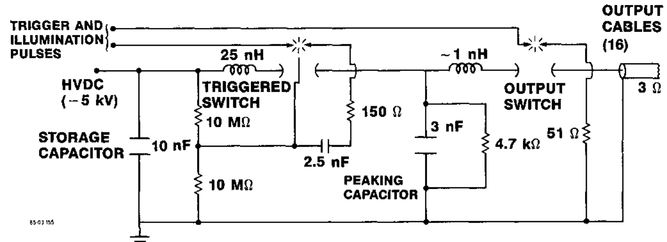

Figure 4. Pulser electrical schematic.

*Work supported by the Defense Nuclear Agency.

The storage capacitor consists of four 2.5-nF ceramic capacitors connected in parallel. They were charged to -5 kV by an external high voltage power supply. The discharge path through the triggered switch to the peaking capacitor is coaxial to minimize inductance and to provide a fast charge time for the peaking capacitor. This ensures minimum output-switch site-to-site jitter. The output switches were designed to fire at maximum dV/dt on the peaking capacitor. The time from triggered switch closure to maximum dV/dt at the output switches is 14 ns. For a measured peaking capacitance of 3 nF, this indicates a circuit inductance of 25 nH.

The main switch is a three-electrode spark gap with a triggered midplane. The trigger pulse was provided by a 10-kV, 10-ns risetime (into a 50-Ω load) pulse generator. The main switch UV-illuminator is located electrically between the trigger pulse source and the switch midplane, thus ensuring that the main switch is illuminated before it receives the trigger pulse. The UV-illuminator is a small surface discharge spark gap located in the switch. As a result of the UV-illumination, the triggered switch has less than 5 ns command jitter. The midplane is dc-biased at 50% of the storage capacitor potential by the use of two 10 MΩ resistors. The midplane is capacitively isolated from the bias circuit by a 2.5-nF capacitor. The gap spacing on each side of the midplane was set to 0.07 cm.

Located in the center of the housing is the peaking capacitor. It is a region of mylar sheet 0.01 cm thick compressed between a grounded metal split ring and the high potential inner conductor. The split ring is connected to the ground return cylinder by 18 short metal screws. By proper tightening of these screws the mylar is compressed by the split ring around its circumference and forms a very low inductance capacitor. Considered as a transmission line, the peaking capacitor characteristic impedance is 0.1 Ω and its length is 0.3 ns. The peaking capacitor is dc-grounded by a 4.7 kΩ resistor.

Initially the output switch consisted of 24 sites connected together on the output side by a solid metal plate. The sites were equally spaced on a 8.6-cm diameter with an illuminator located at the center. The 10 to 90 risetime into 3 Ω was 2 ns. The risetime was slowed by having only a fraction of the sites closing or by jitter in the individual sites. The electrical transit time isolation between gaps on the output side was 100 ps. The risetime was not improved in spite of attempts to overvolt the output switches prior to illumination.

The output switch was then modified to the present design where one switch site drives one cable. The central spark gap illuminator preilluminates the switches and the outputs of the 16 sites are kept electrically separate. This ensures that all of the 16 sites close on each shot. The jitter between individual sites was measured to be a few tenths of a nanosecond. The 10 to 90 risetime of each gap was measured as approximately 600 ps. This indicates that the inductance from the peaking capacitor through the output switches is less than 1 nH. The gap spacings were set to 0.05 cm. The test circuit is shown in Figure 5 and sample waveforms are shown in Figure 6.

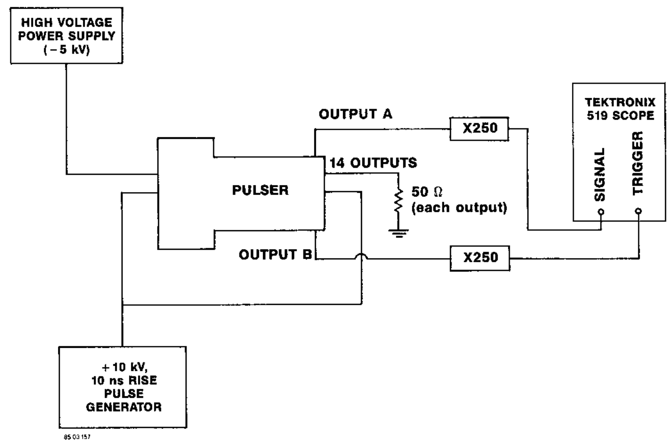

Figure 5. Test setup for measuring output cable jitter. The oscilloscope risetime was measured to be $\lesssim$ 300 ps.

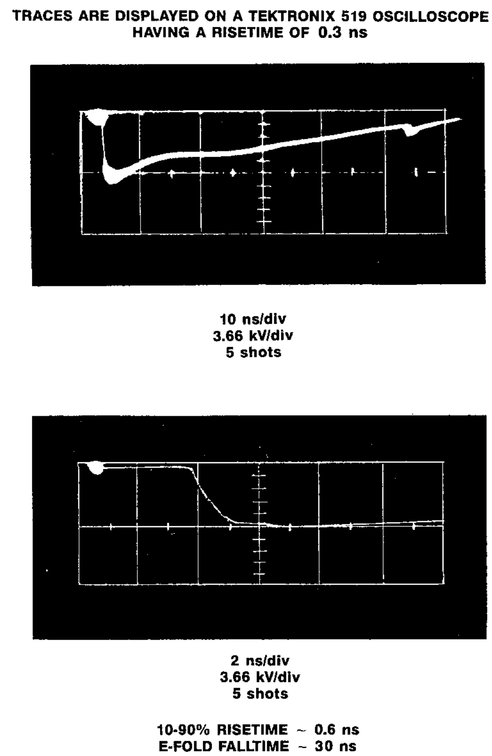

Figure 6. Output pulses measured by experimental arrangement in Figure 5.

Summary

A very fast risetime, low-impedance pulse generator has been constructed. The pulser produces an approximate double exponential output pulse at 3 kV into a 3-Ω load. The output pulse 10 to 90 risetime is 600 ps and 1/e falltime is 30 ns. The pulse generator design is a dynamic peaking capacitor circuit. Inductance is minimized in all components. The pulser output consists of 16 parallel 50-Ω cables driven by 16 individual spark gaps operating synchronously. The pulser was tested and worked reliably.